Impacts and risks to agriculture from climate change: adaptation solutions and the role of new plant varieties

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Content

- Green house gases emission
- Increased temperature and precipitation
- Risks of Climate change
- Case study examples
- Adaptation solutions
- The role of plant breeding

Human influence has warmed the atmosphere, ocean and land since around 1750 (IPCC, 2021 Summary for Policymakers)

Increases in Greenhouse Gas (GHG) concentrations caused by human activities

Land and ocean have taken up ±56% of CO_2 emissions per year over the past 6 decades

Annual average increases of GHGs (2011-2019)

- 410 parts per million (ppm) for carbon dioxide (CO_2)
- 1866 parts per billion (ppb) for methane (CH_4)
- 332 ppb for nitrous oxide (N_2O)

Other GHGs (2019)

- Perfluorocarbons (PFCs) – 109 parts per trillion (ppt) CF4 equivalent;
- Sulphur hexafluoride (SF6) – 10 ppt
- Nitrogen trifluoride (NF3) – 2 ppt
- Hydrofluorocarbons (HFCs) – 237 ppt
- Chlorofluorocarbons (CFCs) and hydrochlorofluorocarbons (HCFCs) – 1032 ppt

IPCC, 2021: Summary for Policymakers. In: Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the **Sixth Assessment Report of the Intergovernmental Panel on Climate Change** [Masson-Delmotte, V., P. Zhai, A. Pirani, S.L. et al (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, pp. 3–32, doi:10.1017/9781009157896.001

As a result of GHG emissions the Global surface temperatures have increased relative to levels of 1850-1900

Each of the last four decades has been successively warmer than any decade that preceded it since 1850.

- 2001–2020 was **0.99** °C [0.84 to 1.10] higher than 1850–1900
- 2011–2020 was **1.09** °C [0.95 to 1.20] higher than 1850–1900
- Larger increases over land of **1.59** °C [1.34 to 1.83] higher than 1850–1900
- Increase over ocean of **0.88** °C [0.68 to 1.01] higher than 1850–1900

IPCC, 2021: Summary for Policymakers. In: Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the **Sixth Assessment Report of the Intergovernmental Panel on Climate Change** [Masson-Delmotte, V., P. Zhai, A. Pirani, S.L. et al (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, pp. 3–32, doi:10.1017/9781009157896.001

Increases in temp & water-related stresses affect global agricultural productivity

Increased productivity in temperate environments

- Increased temperature (1–3^{0}C), CO_2 & rainfall changes
- Extended growing season

A decline in productivity in tropical and subtropical environments

- More frequent extreme weather (drought, heat, flood)
- Lower production by limiting the length of the growing season
- Implications: compromised resource capture and processes underpinning growth and yield

Extreme weather events posing a serious threat to agriculture in the tropics*

- An estimated **21-34% loss in global** agricultural productivity growth since 1961
- About **26-30% in Africa**, Latin America and Caribbean
- Impact of reduce productivity high on small land holding
- Limited technology options
- Reduced availability of agricultural land due to urbanization
- Lack of capital to mitigate

**(Ariel Ortiz-Bobea et al. 2021 Nature Climate Change (VOL 11: 306–312) | www.nature.com/natureclimatechange)*

Excesses of temperature and precipitation - *El Niño & La Niña* events affects agricultural productivity e.g., in Southern Africa

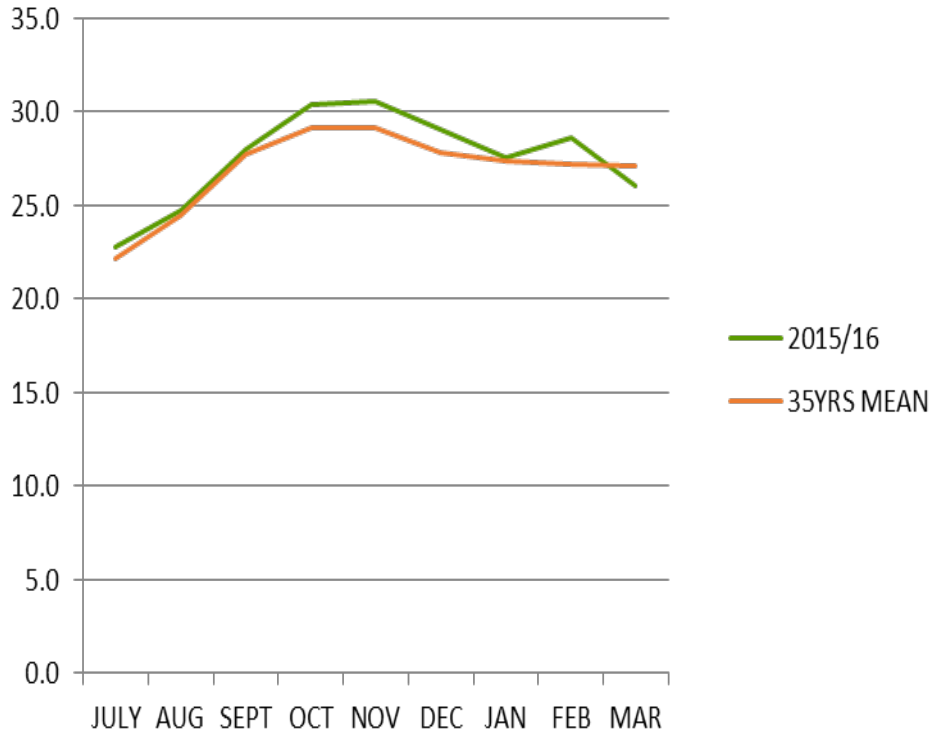
- La Niña years bring the growing conditions closer towards the optimum
- El Niño years result in stress growing conditions of heat & drought
- Rising Jan - Mar temperatures posing a threat to agricultural productivity growth
- Increasing dry spell duration during the reproductive growth stages reduce maize yields
- Increasing wet spell duration leads to waterlogging
  - Excessive wetness reduce maize yield
- Maize yield decreases associated with *El Niño* events tend to be larger than corresponding yield increases during La Niña events.

Unprecedented climate extremes in South Africa and implications for maize production. Catherine D Bradshaw et al 2022 Environ. Res. Lett. 17 084028

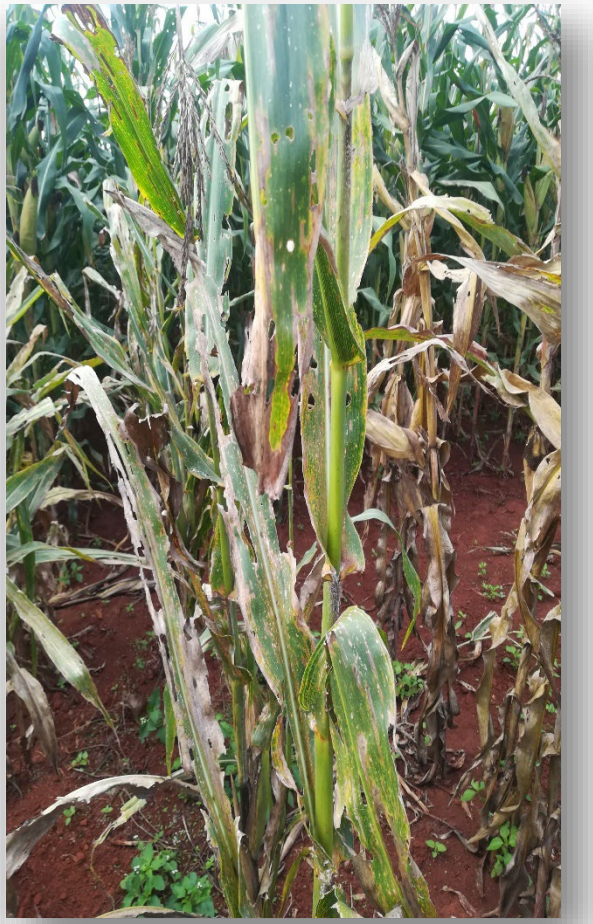
Maximum temperature increases at Rattray Arnold Research Station, Zimbabwe, during El Niño in 2015-16, 1990-1991 vs 35-yr mean

Season	JUL	AUG	SEPT	OCT	NOV	DEC	JAN	FEB	MAR
2015/16	22.8	24.7	28.0	30.4	30.6	29.1	27.6	28.6	26.1
35-yr mean	22.2	24.5	27.7	29.2	29.2	27.8	27.4	27.2	27.1
Change	0.6	0.2	0.3	1.2	1.4	1.3	0.2	1.4	- 1.0

Season	JUL	AUG	SEPT	OCT	NOV	DEC	JAN	FEB	MAR
1990/91	25.3	24.8	28.2	31.7	31.2	31.0	29.2	29.9	29.7
34-yr mean	22.1	24.5	27.7	29.1	29.1	27.7	27.4	27.1	27.1
Change	3.2	0.3	0.5	2.6	2.1	3.3	1.8	2.8	2.6



Rising temperatures support Emergence of new pests in new places – the case of devastating fall armyworm in sub-Saharan Africa

Adaptation solutions & the role of new plant varieties

Agriculture contributes to climate change

- Agricultural emissions contribute about 25% GHGs which must be reduced
- Conversion of forests to agricultural land

Therefore, there is need to adopt agricultural practices that contribute to capturing the excess carbon generated by agriculture, and other industries

- Intensification of agriculture will reduce deforestation
- Reducing tillage, expanding crop rotations, planting cover crops
- Integrating livestock into crop production systems
- Irrigation
- Breeding climate change resilient crop varieties

CGIAR Research program on climate change and food security


Nutrition, Health & Food Security


Poverty Reduction, Livelihoods & Jobs

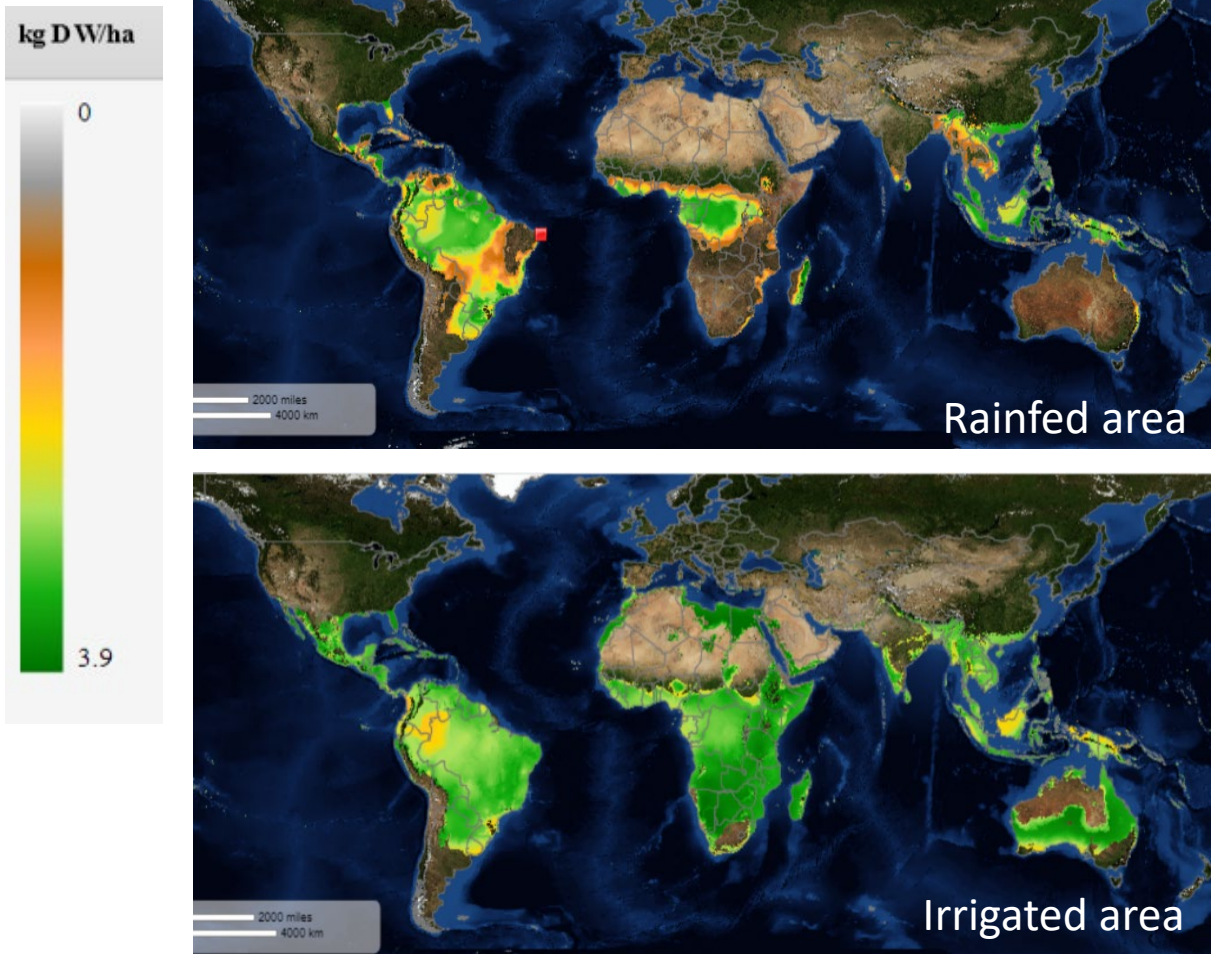

Gender Equality, Youth & Social Inclusion


Climate Adaptation & Mitigation


Environmental Health & Biodiversity

- Research on climate-smart technologies and practices to transition to climate-smart agriculture at a large scale
- Reduction of GHG emissions and increase carbon sequestration in the agriculture sector
- Effective climate information & advisory services for farmers and climate-informed safety net interventions
- Increased production and distribution of burdens and benefits in agriculture among women and men
- Fast-track solutions to millions of farmers and food system actors

Agronomic interventions such as irrigation can increase banana production area and productivity

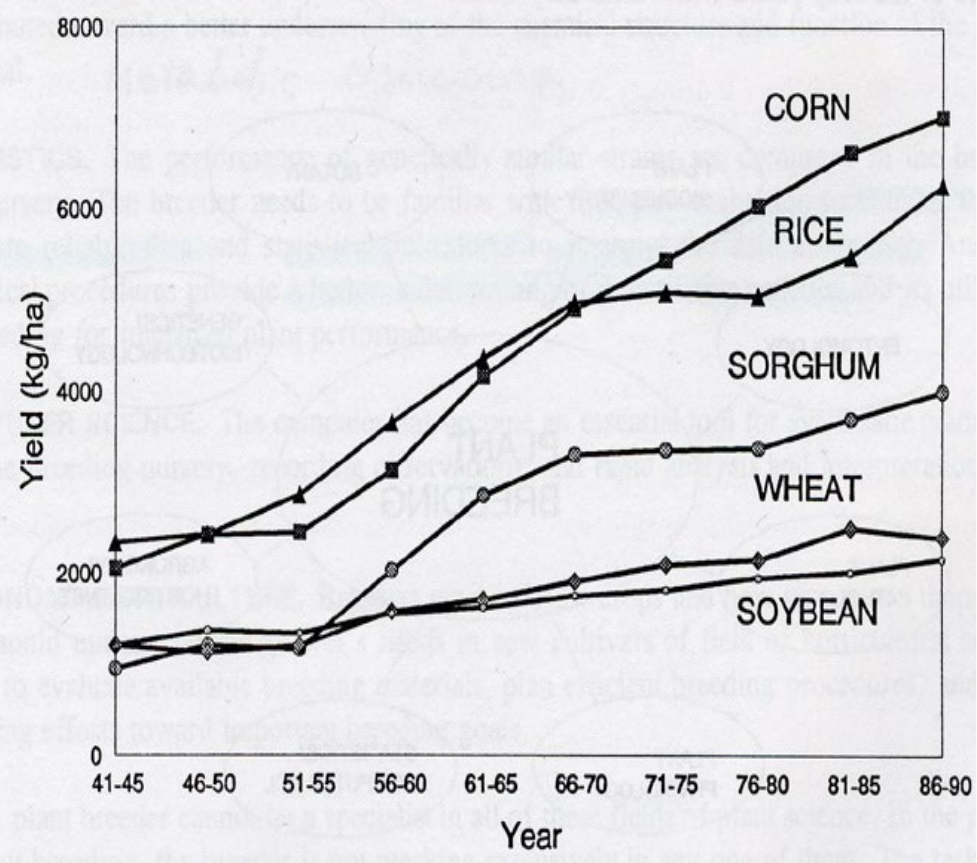


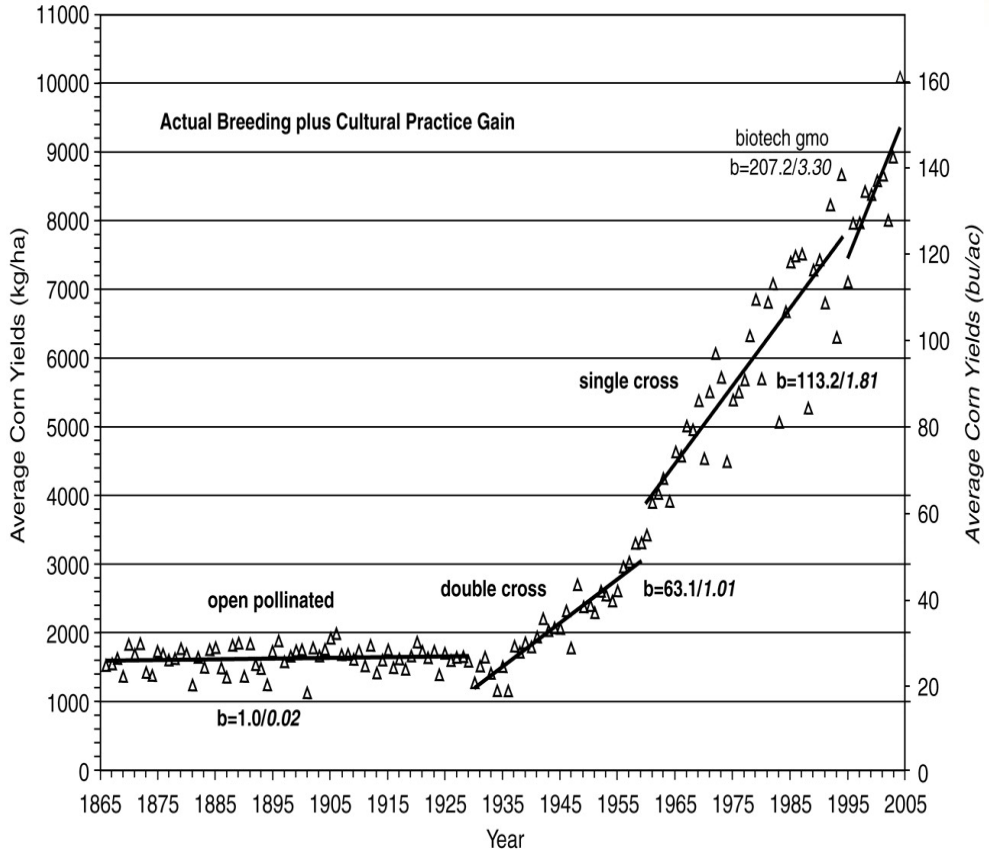
Courtesy, Bioscience Engineering, Biosystems, TPL

Left: Leaf folding due to moisture stress.

Below: Areal imaging of banana canopy show leaf area index changes due to moisture stress

The role of new plant varieties- incredible yield improvements in a changing climate – a result of genetics improvements

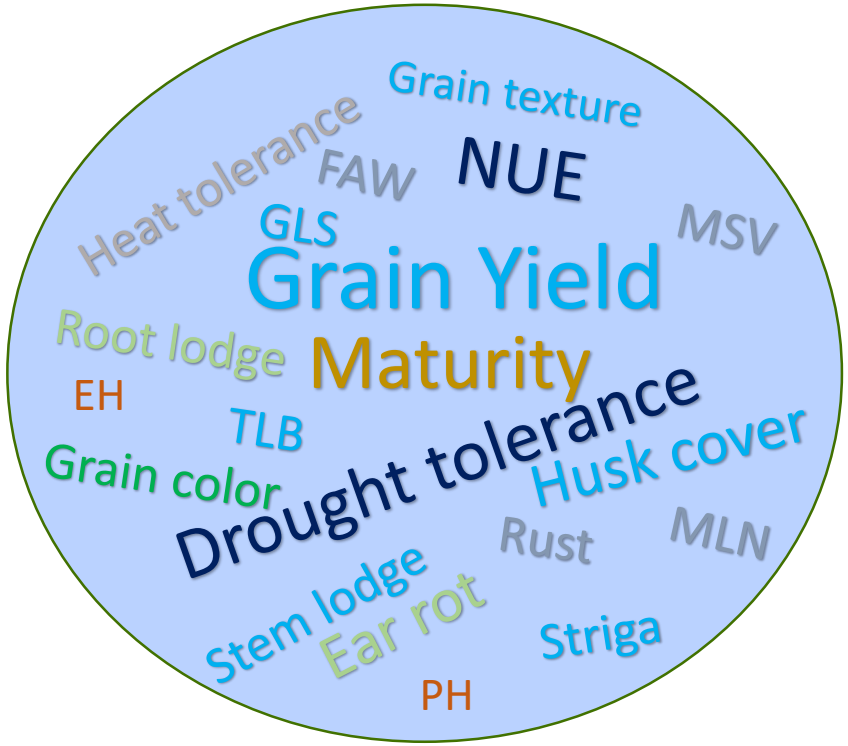




- At least 50-60% of yield increases of USA maize (corn) is attributable to genetic improvement
- CGIAR breeding programs target variety improvements for disease and pest resistance, and abiotic stress resistance (high/low temperature, excessive water/flooding, drought, high salinity, alkaline soils).
- This results in continual increase of genetic gain under climate challenges

CIMMYT & IITA have made a tremendous progress to deliver climate smart maize varieties

Multiple traits improved to adapt maize to climate change challenges



No.	Country	# hybrids	Center
1	Ethiopia	2	CIMMYT
2	Ghana	5	IITA
3	Kenya	8	CIMMYT
4	Malawi	4	CIMMYT
5	Mozambique	1	CIMMYT
6	Nigeria	20	IITA/CIMMYT
7	Rwanda	4	CIMMYT
8	Tanzania	2	CIMMYT
9	Zambia	15	CIMMYT/IITA
10	Zimbabwe	8	CIMMYT

Accelerated Genetic Gain (AGG) project making significant gains in delivering stress tolerant & input responsive maize varieties. 69 new varieties deployed across SSA in 2020-2021. Yield levels of 9-15 t/ha recorded.

Conclusion

Climate change could cause catastrophic effects on agricultural productivity through increases of GHG emission

Agriculture contributes to climate change therefore, there is need to adopt agricultural practices that contribute to capturing the excess carbon generated by agriculture, and other industries

Improved agronomic practices and development of new plant varieties could contribute to incredible yield improvements in a changing climate

Thank You!

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Science for a food-secure future